COMPARISON OF VIBRATION AND OIL ANALYSIS

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Abstract: This paper demonstrates that the use of just one Predictive Maintenance technology is handicapping the analyst. The merging of technologies can produce earlier and better fault detection. This paper covers Hard Particle Oil Analysis and Vibration Analysis on a system that uses piston type hydraulic pumps.

Key Words: Hard particle oil analysis; vibration analysis

For many years, Vibration Analysis has been the cornerstone, if not the sole component, of the majority of successful Predictive Monitoring Programs. Vibration Analysis is still the foundation, but other technologies have evolved to augment vibration data in equipment condition assessment.

The merging of Predictive Maintenance technologies allows for earlier and better machinery condition determination than the use of a single method. There are many technologies; for example : Vibration Analysis, Hard Particle Oil Analysis, Infrared Spectrography Oil Analysis, Ferrography, Thermography, Ultrasonic Analysis and Passive Electric Current Analysis that could be used together. Each technology has its nitch in detecting certain machinery faults, but when used together as a team, few problems can go undetected.

Several hydraulic systems are used on a metal rolling mill. One system maintains the proper gap of the rolls and is referred to as the SGC system on this particular machine. The SGC hydraulic system has six (6) servo valves, six (6) actuators and operates at 3650 PSI. There are three (3) piston type hydraulic pumps, of which any two (2) are required to run for proper system operation.

Table I

Number of particles per ml		R
More than	Up to & including	Range Numbers
80,000	160,000	24
40,000	80,000	23
20,000	40,000	22
10,000	20,000	21
5,000	10,000	20
2,500	5,000	19
1,300	2,500	18
640	1,300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9
1.3	2.5	8
0.64	1.3	7
0.32	0.64	6
0.16	0.32	5
0.08	0.16	4
0.04	0.08	3
0.02	0.04	2
0.01	0.02	1

This rolling mill performs the first four passes of the metal and then the metal goes to trimming for shipment or on to a pair of final mills for even further reduction. If the proper gap is not maintained, quality suffers on further reduction and can cause entire coils to be scraped. The good operation of the SGC system is important to this plant. In the past, the SGC system had experienced failures of the servo valves and actuators due to contamination related problems. The servo valves would be erratic or stick open. The actuators would be slow to react to changes or fail to maintain appropriate pressure.

The plant was using vibration monitoring to assess the condition of the hydraulic pumps. This technology was not suited to offer any insight into the contamination problems with the hydraulic system. The plant decided to employ the Predictive Maintenance technique of hard particle counts of the hydraulic oil on a monthly basis. This technique would tell the plant personnel that there was contamination present and quantify the level. Alarm levels (Target Cleanliness) were set to initiate action to address the contamination. Hard particle counts would identify if there was a problem and by dividing the system into subsets; such as, pumps, tank, actuators, could identify the source of the contamination.

Target Cleanliness is the measure of maximum number of contaminates allowed in the oil system being measured. This target should allow for continued good operation of the oil system. The particles are counted as greater than 5 micron and as greater than 15 micron. A micron is 0.000001 meter. A human hair is approximately 80 microns thick. The unaided eye can not see below 50 microns. The particle counts, number of contaminates present, are divided into numeric levels, Range Numbers, called ISO (International Standards Organization) codes.

Each increase in the ISO Range Numbers doubles the upper limit of particles. The ISO codes shown in Table 1 are numeric ranges. For example, an ISO code of 21 would mean the number of particles present in a milliliter (ml) of liquid would be greater than 10,000 but not more than 20,000. The Target Cleanliness is expressed by two ranges, R 5 micron / R 15 micron. The lower the R number means the cleaner the oil system is. R 5 micron is the number of particles greater than 5 micron. R 15 micron is the number of particles greater than 15 micron.

To establish a Target Cleanliness for the SGC system, several factors were taken into account. Some of the factors were; the mill is a high initial expenditure, downtime is expensive, quality is very important, safety is an issue due to fire hazard, high pressure oil, multiple servo valves with tight clearances, air borne particles minimal and possible water contamination due to coolers. An ISO code of 14/11 was chosen for the SGC system Target Cleanliness. This means that the maximum number of particles of greater than 5 micron would be 160 and the maximum number of particles of greater than 5 micron would be 20. The SGC system has an auxiliary makeup tank that is equipped with a 10 micron filter. The oil is circulated through the filter to clean the hydraulic oil before it is added to the SGC system.

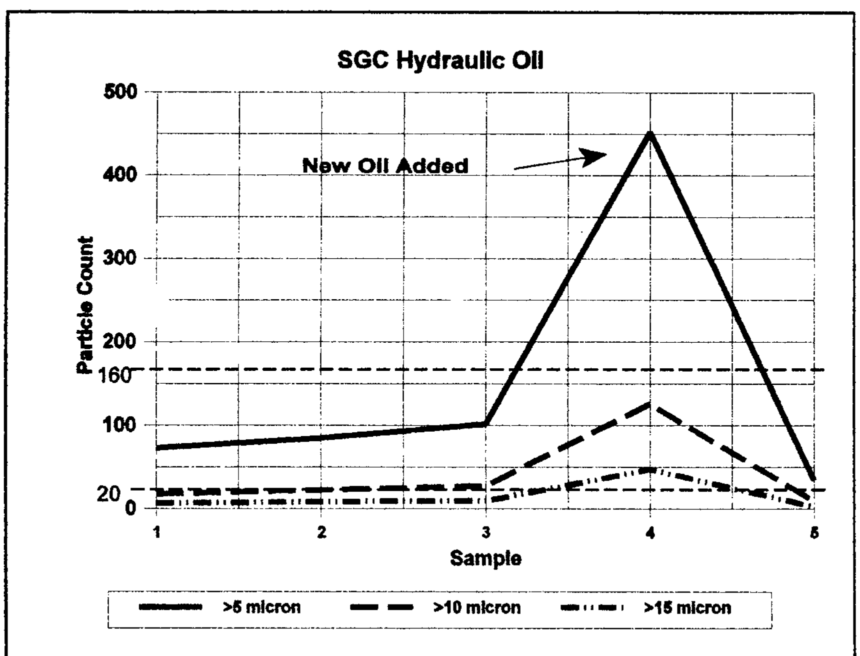

Figure 1

The first samples were within Target Cleanliness of 14/11. The fourth sample jumped into alarm with a 16/13. Figure 1 shows the trend of the hard particle counts. Samples were taken from the tank, from after the pumps, from after the filter and from the return line to try to determine where the contamination was occurring. Also, operating and maintenance records were checked for any activity involving the SGC system. The tank contents were the source of the contamination.

Before the fourth sample was taken, the system was losing hydraulic oil. On the night shift, a mechanic from another portion of the plant was assigned to top off the SGC tank. The mechanic added hydraulic oil from a new barrel to the system instead of using the oil that had been cleaned in the auxiliary tank. The new oil had an ISO code of 21/18 which is typical for hydraulic oil fresh from the barrel. Adding the new oil to the SGC system contaminated it. Administrative procedures were put in place to eliminate this source of contamination in the future.

The fifth sample showed the SGC system's 6 micron filter on the tank removed the contamination and the system returned to below a 14/11.

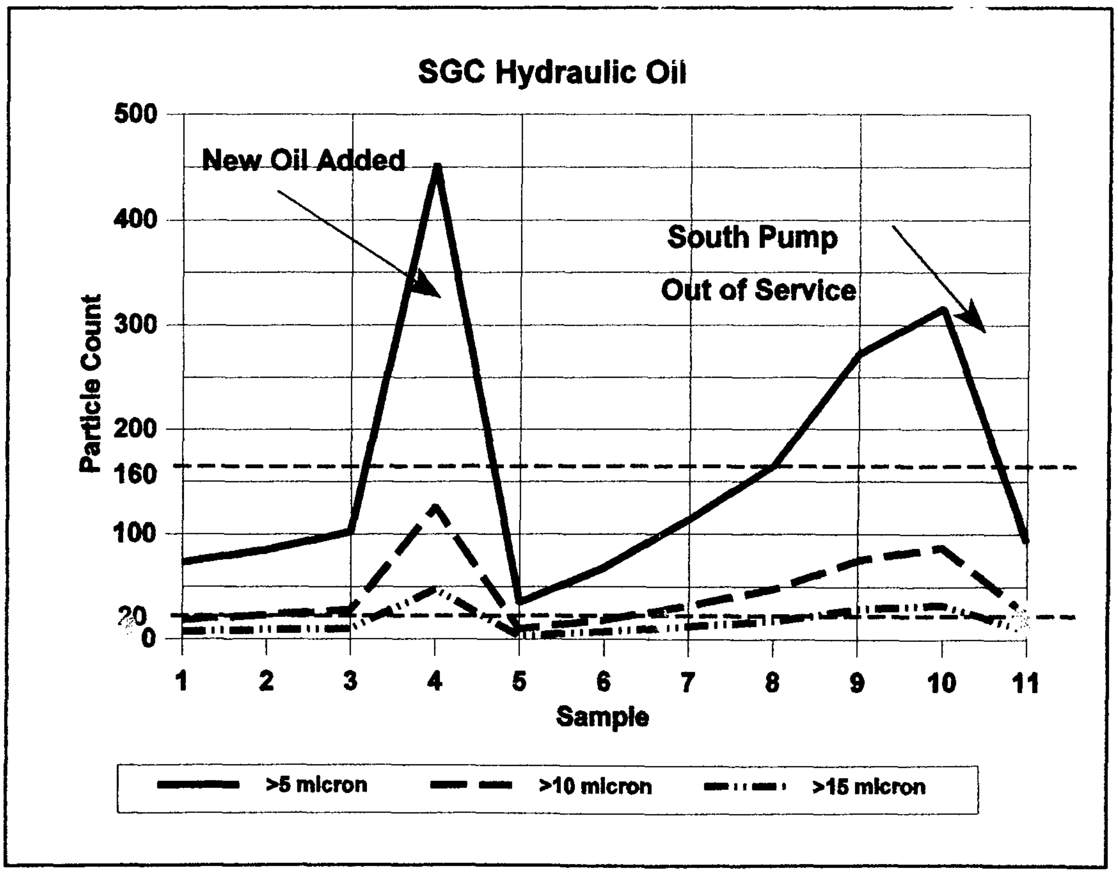

Figure 2

The particle counts increased over the next several samples and went into alarm (figure 2)

on sample 8. The particle counts continued to rise to an ISO code of 15/12. Again, samples were taken from the tank, from after the pumps, from after the filter and from the return line to try to determine where the contamination was occurring. The samples indicated the South Pump was producing particles. The vibration data was checked (figure 3) and revealed no apparent problems. The overall and bandwidth amplitudes had not increased significantly over the past few months.

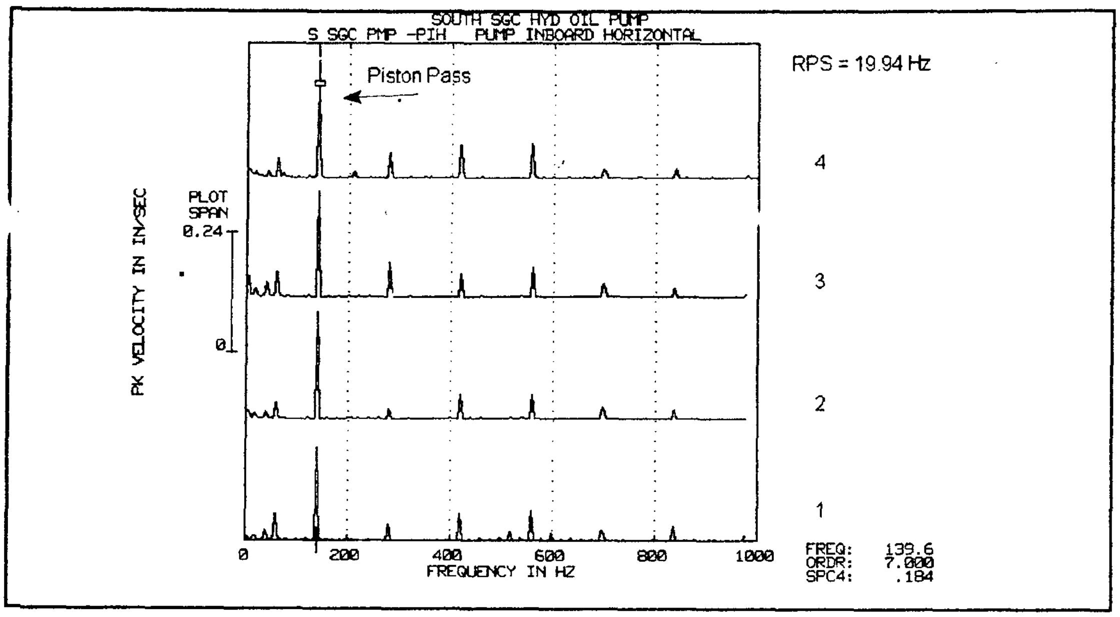

Figure 3

The Center Pump was started and the South Pump was removed from service. The particle counts at sample 11 dropped back to below an ISO code of 14/11 (figure 2). The South Pump was disassembled and scoring of the cylinder walls was found. Parts were ordered to rebuild the hydraulic pump.

The SGC system now had the Center and North Pumps in service. As stated above for reliable and safe operation two pumps were required to be in service. The particle counts started to climb again. By sample 12, the particle counts were in alarm at an ISO code of 15/12. Samples were taken from the tank, from after the pumps, from after the filter and from the return line to try to determine where the contamination was occurring. The samples indicated the North Pump was producing particles. The rolling mill was out of service for maintenance, so the SGC system was run with just the Center Pump in service. After one day the particle counts, sample 15, dropped down, though were still just in alarm (figure 4).

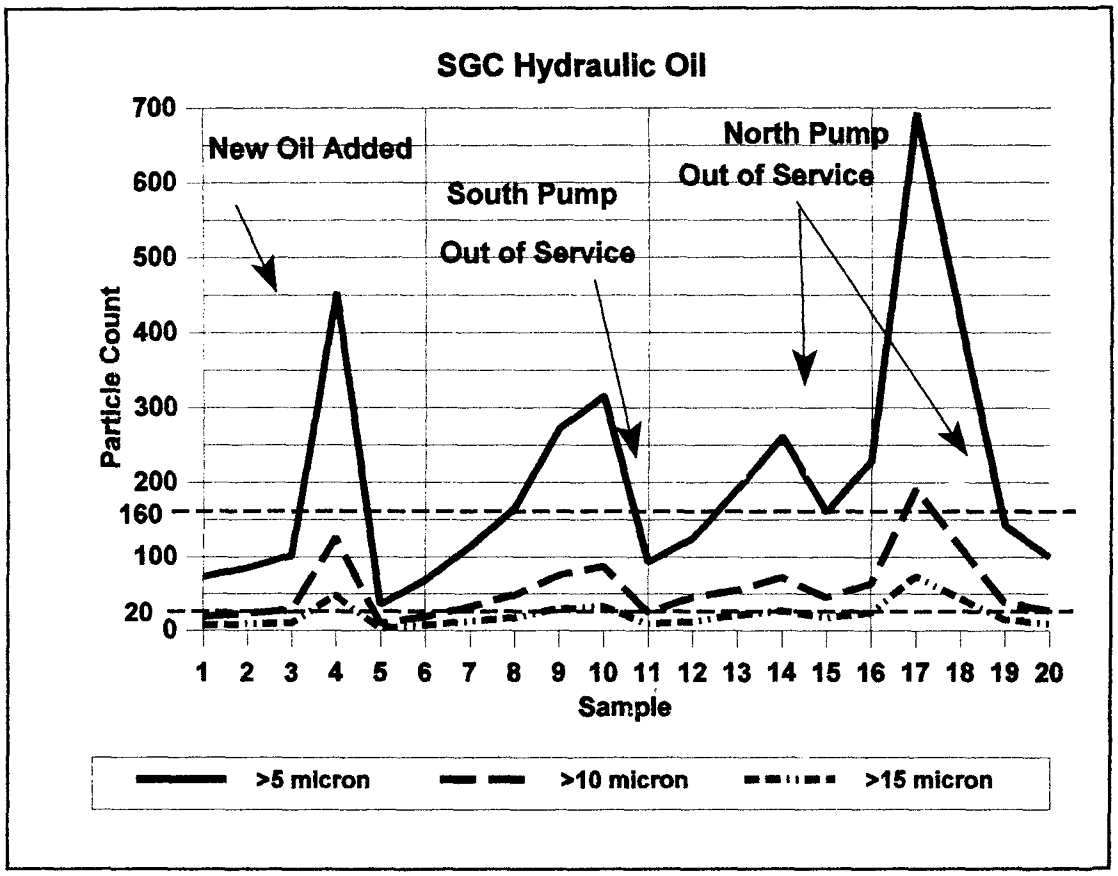

Figure 4

Since the parts had not arrived to repair the South Pump, the North Pump was returned to service. The particle counts continued to rise while the South Pump was being reassembled. After six weeks, the particle counts peaked at an ISO code of 17/14 (figure 4). Two servo valves had to be changed during this time due to contamination binding the valve stem and rendering the valve inoperable.

The vibration data began to show indications of a problem (figure 5). The vibration at piston pass frequency, 7X, increased significantly. The peak vibration increased from 0.11 in/sec to 0.31 in/sec. Also, 1X sidebands of the pump speed appeared around the piston pass center frequency.

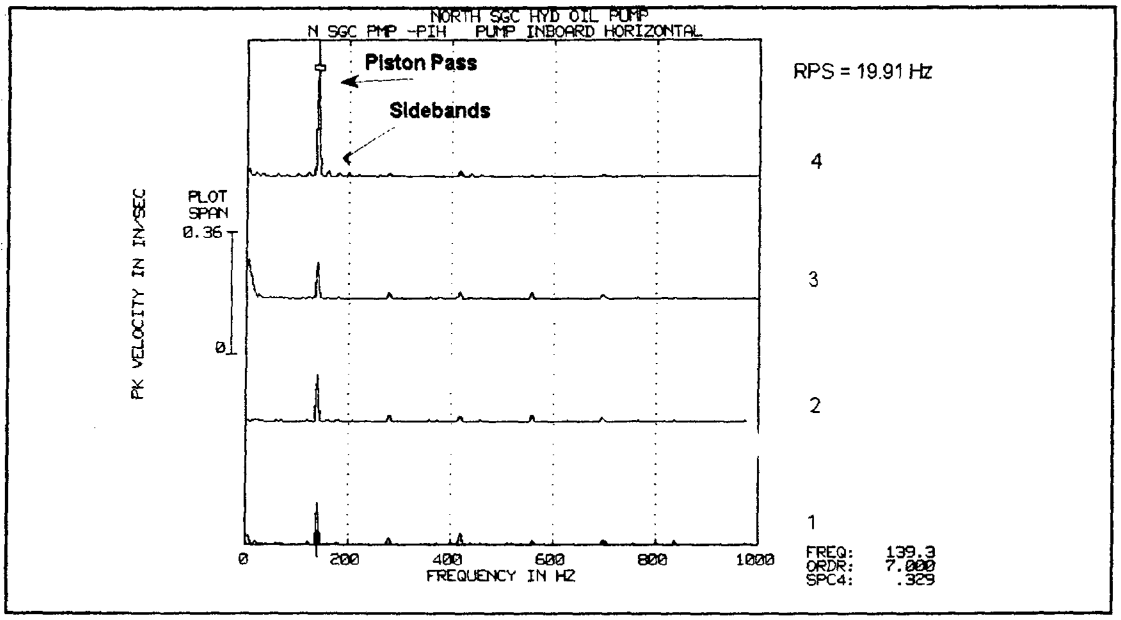

Figure 5

Vibration monitoring and analysis did show that the SGC system hydraulic pumps had a problem developing. The spectra and timewave data began to indicate there was a piston related event. The Hard Particle Counts of the hydraulic oil gave warning of the piston problem approximately six (6) months before the vibration data. The North Pump had scoring of the walls, too.

As this shows, having more than one analysis tool for the analyst to use will help identify problems sooner. Multiple Predictive Maintenance techniques work well together in an organized, well thought out program. One technique is not the answer for every problem.